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(54) **Alignment aid.**

(57) An alignment aid for facilitating the accurate superposition of two or more transparencies comprises one or more regions of markings, the marking being such that the superposition of the alignment aids of two or more transparencies in any position other than in predetermined absolute alignment will form one or more moiré fringes.

The alignment aid conveniently comprises one or more concentric spirals, a plurality of concentric ellipses having a common major axis, or a region of concentric circles together with a region comprising a plurality of straight lines parallel one with another.

ALIGNMENT AID

This invention relates to an alignment aid for facilitating the accurate superposition of two or more transparencies.

It is necessary to superimpose photographic transparencies accurately in a number of optical processes. Optical metrology is concerned with extremely accurate measurement. In one metrological method commonly known as Moire topography, a grating of equi-spaced parallel lines is projected on to the object to be measured and photographs are taken of the grating projected on to the object and also on to a flat reference screen. When the two photographic transparencies are superimposed the gratings combine to give Moire fringes in the form of contour lines representing the relief of the object. As the position of the contour lines depends upon the phase of the two observed gratings it is necessary to be able to superimpose the transparencies accurately in order to give precise values to each of the contour lines produced.

Moire fringes are also used in a variation of the above described technique to measure the deformation of a subject material under stress. A grating is projected on to the object under test and photographic transparencies are produced of the object when relaxed and when stressed. When the two transparencies are superimposed Moire fringes are produced which can be recorded and interpreted to give information about the surface deformation of the object.

In both of the above described metrological techniques it is imperative that the transparencies shall be accurately superimposed as regards both rotational and translational displacements. To help achieve this it is common to include in the information recorded on the photographic transparency one or more alignment aids in the form of crosswires or segmented circles. Often the alignment achievable with the unaided human eye is not sufficiently precise and the alignment aids must each be viewed through a microscope in order to detect the position of best alignment. Since up to four alignment aids may be present on each transparency and each one must repeatedly be viewed microscopically, the accurate superposition of the transparencies is a skilled and lengthy process.

There thus exists a need for an alignment aid which is capable of facilitating simple, quick and accurate alignment between two superimposed transparencies in both rotational and translational

senses, ie so that no degree of freedom remains for misalignment. Such alignment is herein termed 'absolute alignment', and the present invention seeks to satisfy this need.

5 The invention depends upon use of a Moire fringe effect between superimposed patterns. Moire fringes effects are primarily being utilised for Moire topography as described hereinbefore, and in devices for the accurate measurement of displacement. The Applicant is also aware of two prior proposals from very different arts in which the effect is used as an alignment aid.

10 In one case, as an aid to the angular alignment of inclined blast holes, closely spaced parallel lines are engraved on a pair of parallel acrylic plates, one fixed, the other freely pivoted under gravity. As light passes through, an interference pattern of broad arrows is formed when the two plates are out of angular alignment.
15 This effect is utilised to align the drill accurately at the same angle for successive bores.

In the other case, as disclosed in UK Patent No 1174781, an alignment aid for the positioning of colour negatives so as to obtain accurate registration thereof, comprises a pattern of concentric
20 rings on each member to be aligned. Any translational displacement between the members when superimposed is indicated by a Moire fringe pattern set up between the two sets of markings.

These two prior art systems enable greatly increased accuracy to be achieved with direct visual observation, ie without the use of
25 magnification devices. However, both suffer from the shortcoming that neither is capable of facilitating absolute alignment. In the one case, parallel lines cannot indicate a translational displacement, and in the other case, the pattern of circles cannot indicate an angular displacement.

30 As noted hereinbefore, accurate alignment of transparencies requires absolute alignment, and the presently employed method involving up to four alignment aids is time consuming. It would be possible to envisage a system based on the disclosure of UK Patent No 1174781 having eg a pattern of circles in opposite corners of a
35 transparency. A similar scheme with two patterns of parallel lines would not provide information about translational alignment. In any event, although a Moire fringe system would in many instances avoid the necessity for magnification by a microscope, the need for two or

more alignment aids displaced one from another renders the alignment process tedious, because of the need to check repeatedly that adjustment of one alignment aid has not displaced another.

5 The present invention provides an article carrying an alignment aid based on the use of Moire interference fringes which avoids this difficulty, to the extent that even for highly accurate work requiring the use of a microscope, the alignment process is rendered very simple and straightforward.

10 Thus, according to one aspect of the invention, there is provided an article having an alignment aid thereon comprising a single region of markings in the form of closely spaced lines, the arrangement of lines within the single region being such that on superimposition of such an alignment aid on a transparency over such an alignment on another article, Moire fringes are formed by interaction
15 of the superimposed markings of the respective single regions, unless the alignment aids are aligned in both translational and angular senses.

Preferably, adjacent lines of the markings are equispaced one from another. This will help to produce a regular pattern of Moire
20 fringes when superimposed alignment aids are misaligned, making the fringes easier to interpret.

The alignment aid conveniently comprises a region of markings comprising a spiral or at least two concentric spirals. Two identical regions of such spiral markings superimposed one upon the
25 other in absolute alignment will retain the appearance of a spiral. If, however, the two spirals are laterally offset one from the other, the misalignment will cause the regions of markings to produce Moire fringes. The regions will not retain the appearance of the original spirals but dark fringes extending radially from the centre of the
30 spirals, and easily observable with the naked eye, will be present. The first Moire fringe will begin to appear when the alignment aids are laterally offset one from the other (ie translationally misaligned) by one half of the spacing between adjacent lines of the spiral.

35 If the two spiral markings are translationally in alignment but rotationally misaligned then one or more circular Moire fringes appear, concentric about the centre of the spirals. The misalignment necessary to produce the first Moire fringe will be dependent, for a

single spiral, on the line density (the pitch of the spiral). The sensitivity may be increased by employing two or more nested concentric spirals (ie an overall spiral region with several 'starts').

5 In an alternative embodiment the alignment aid comprises a single region of markings in the form of a zone consisting of a plurality of concentric circles, surrounded by a zone consisting of a plurality of straight lines parallel one with another. Two such alignment aids which are superimposed yet translationally misaligned cause radially extending fringes to appear on the zone of concentric circles. As with the spiral markings previously described, the first Moire fringe will begin to appear when the alignment aids are laterally offset by one half of the spacing between adjacent circles. No fringes will be observed in the zone of parallel lines because translational misalignment between two such patterns of markings
10 without rotation will still leave the lines parallel one with the other.

If two such alignment aids are translationally aligned and yet rotationally misaligned no fringes will be observed in the zone of concentric circles. However one or more dark interference fringes
20 will appear on the zone of parallel lines. The spacing S, between adjacent fringes on the zone of parallel lines is given by the equation:

$$S = \frac{P}{2 \sin(A)} \dots\dots(1)$$

(2)

25 where p is the spacing between adjacent parallel lines, and

A is the rotational angle through which the two alignment aids are misaligned.

The combination of the zone of concentric circles to detect lateral misalignment and the zone of parallel straight lines to detect anngular misalignment ensures that Moire fringes are always observable except when the two or more alignment aids are in absolute alignment one with another, ie both rotationally and translationally aligned.

35 In a further alternative embodiment the alignment aid comprises a region of markings in the form of a plurality of concentric ellipses having a common major axis. Misalignment between two or more regions of elliptical markings produces one or more Moire

interference fringes extending radially outwardly from each of the two foci common to each of the concentric ellipses. These fringes will only disappear and the markings resume a uniform appearance when the alignment aids are in absolute alignment, ie with the ellipses superimposed exactly one upon another without angular or translational misalignment.

In order not to interfere with the information recorded on the transparency, a rectangular transparency according to the present invention will normally have an alignment aid as described above positioned in one of its four corners, or adjacent an edge thereof.

According to another aspect of the invention, a process for reproducing an image of an original representation comprises the steps of

applying to the original representation an alignment aid so as to create an article in accordance with any one preceding claim, preparing a plurality of transparencies each representing a component of the original representation and each including a reproduction of the alignment aid,

and reproducing an image of each transparency in turn, successive images being superimposed in accurate alignment by use of the reproductions of the alignment aid.

The original representation may be a colour photograph, each transparency representing a monochrome component thereof, and each transparency being subjected to colour correction prior to reproduction of an image thereof.

Alternatively, the original representation may be in colour, each transparency representing a monochrome component thereof, an image of each transparency including the alignment aid being reproduced on a respective printing plate, and a monochrome image of each transparency being printed from its respective plate, successive images being superimposed in accurate alignment by use of reproductions of the alignment aid.

According to a still further aspect of the invention there is provided a process for the production of a double sided printed circuit board, comprising the steps of

preparing two master transparencies each representing the conductive pattern to be applied to one side of the board,

including on each master transparency an alignment aid so as to create an article in accordance with the invention, the alignment aid being so positioned as to fall outside the boundary of the board when aligned therewith,

5 superimposing and aligning the two master transparencies on opposite sides of the board by use of superimposed alignment aids, and

transferring the pattern of the two master transparencies to the opposite sides of the board.

10 The invention will now be more particularly described, by way of example only, with reference to the accompanying drawings, in which

Figure 1 is a view of a part of a transparency in accordance with the invention carrying an alignment aid in the form of a pattern of spirals,

15 Figure 2 is a view of the alignment aid of Figure 1 superimposed upon another similar aid but angularly misaligned with respect thereto,

Figure 3 is a view of the alignment aid of Figure 1 superimposed upon another similar aid, but translationally misaligned with respect
20 thereto,

Figure 4 is a view of part of a transparency carrying another form of alignment aid according to the present invention,

Figure 5 is a view of the alignment aid of Figure 4 shown when superimposed upon an identical alignment aid and translationally
25 misaligned with respect thereto,

Figure 6 is a view of the alignment aid of Figure 4 shown when superimposed upon an identical alignment aid and angularly misaligned with respect thereof, and

Figure 7 is a view of the alignment aid of Figure 4 shown when
30 superimposed upon an identical alignment aid and misaligned both translationally and angularly with respect thereto.

The alignment aid shown in Figure 1 comprises a a pattern of five nested spirals, ie a five-start spiral pattern. The maximum diameter of the pattern is not greater than about 1cm, and the line
35 density is about 100 lines/mm. With such an arrangement, alignment sensitivity of the order of 5×10^{-6} m is easily achieved.

Figure 2 shows the effect of angular misalignment between two similar superimposed alignment aids. As seen therein, a circular

Moire fringe 2 is produced in the spiral pattern.

Figure 3 shows the effect of a purely translational displacement. In this case a pattern of radially disposed Moire fringes 3 is created.

5 The alignment aid shown in Figures 1-3 occupies only very small proportion of the surface of the transparency, and the complete alignment aid occupies only a single small region adjacent the perimeter of the transparency (eg in a corner or near an edge).

10 Accurate alignment of even a large transparency is made simple, by direct visual observation of a single small region. Normally microscopic observation is unnecessary, although a microscope can be used if exceptional accuracy is required. The whole procedure is much simplified as compared to any prior proposal, particularly in that the need for repeated observation of several widely spaced
15 alignment aids is avoided.

 The boundary of the alignment aid of Figure 4 is generally circular as shown at 11 (although no special importance attaches to this particular shape). It comprises an inner zone or portion 12 and an outer zone or portion 13. The inner portion 12 comprises markings
20 14 in the form of a plurality of concentric circles, equispaced one from another. The outer portion 13 comprises a different set of markings 15 in the form of a plurality of straight lines parallel one with another.

 The alignment aid 11 is present in one corner of each of two
25 transparencies which require to be accurately superimposed one upon another. When the transparencies are in absolute alignment one upon another the markings of the alignment aids are exactly superimposed and the alignment aid 11 retains the appearance of the markings 14 and 15 as shown in Figure 4.

30 Figure 5 shows the effect of a small translational misalignment between two superimposed alignment aids of the kind shown in Figure 4. The translational misalignment has no affect upon the appearance of the straight line markings 15 but causes dark fringes 16 to appear in the portion 12 containing the concentric circles 14. As stated
35 previously the first fringe is observable once the alignment aids are misaligned by one half of the spacing between adjacent circles. Line densities of up to 200 per mm may be recorded on a photographic transparency without resorting to the use of specialised lenses.

This means that the first Moire fringe is observed when the alignment aids 11 are misaligned by only 2.5 microns. This accuracy is furthermore obtained without the need for magnification of the alignment aid for the fringes 16 are clearly visible to the naked eye.

Figure 6 shows the effect of the superposition of the two alignment aids 11 in translational alignment but with one alignment aid rotated relative to the other by a small amount. The angular misalignment has no apparent effect on the portion 12 containing the circular markings 14 which retain their original appearance as in Figure 4. However dark Moire interference fringes 17 are observed in the portion 13 containing the grid of parallel straight lines 15. Assuming once again a line density of 200 per mm, and also assuming the alignment aid 11 to have a diameter of about 1 cm in the corner of a transparency, equation (1) predicts that an angular misalignment of 0.03° can be detected by a single alignment aid.

Figure 7 shows an alignment aid 11 with fringes 16 and 17 in both portions 12 and 13 due to misalignment both translationally and angularly. An operator in aligning two transparencies will move one transparency relative to the other so as to eliminate the fringes 16, 17 in both portions of the alignment aid. The requirement for microscopically viewing each alignment aid individually as in prior art devices is thereby eliminated.

An important use for an alignment aid according to the present invention is in the photographic printing process. In order to carry out colour balancing and adjustment a single photograph is split up into several monochrome transparencies typically one black and one for each primary colour. An alignment aid applied to the original photograph is reproduced on each monochrome transparency. Colour correction is then carried out on each separate transparency before all the transparencies are superimposed to produce the required master negative. Use of the alignment aids reproduced on each transparency enables quick and accurate absolute alignment of the individual transparencies, in order to produce a colour corrected reproduction of the original.

In some colour printing processes such as offset lithography, only one colour of ink can be deposited on to the paper at any one time. Therefore the original colour photograph or other representa-

tion must be split into several monochrome transparencies to enable individual printing plates to be made for each required colour. An alignment aid of the kind provided by the present invention, incorporated on to the border of the colour photograph, will ensure that
5 each monochrome transparency has an alignment aid thereon. By transferring the alignment aid from one transparency on to each of the plates to be used (typically by photochemical etching), subsequent monochrome transparencies can be accurately aligned each with its respective printing plate. This will help to ensure that each
10 printing plate deposits its coloured ink in the correct position relative to those already on the paper.

A further use for the alignment aid is in the manufacture of double sided printed circuit boards. Typically the conductive pattern on a printed circuit board is formed by transferring the
15 pattern from a 'master' transparency to the board by photochemical etching. It is common practice to transfer patterns to both sides of the board, either for the purpose of mounting the maximum amount of electronic circuitry on the board or for the purpose of shielding the circuit from electrical interference. When patterns are applied to
20 both sides of the board, they must be aligned to ensure that components mounted on one side of the board remain electrically isolated from components or conductive tracks on the other side.

Since the two master transparencies are separated by the board, alignment cannot be made by visually inspecting the registration of
25 the two patterns. For this reason, it is necessary to provide some alternative means for achieving accurate superposition of the transparencies on opposite sides of the board. This can very conveniently be done by the provision of an alignment aid according to the invention near the perimeter of each master transparency. The board is
30 then placed between the two master transparencies so that the alignment aids fall outside its boundary. The transparencies can thus be accurately registered in absolute alignment by direct visual inspection and adjustment, prior to transfer of the conductive pattern from the transparencies to the board.

Claims

1. An article having an alignment aid thereon comprising a single region of markings in the form of closely spaced lines, the arrangement of lines within the single region being such that on superimposition of such an alignment aid on a transparency over such an alignment aid on another article, Moire fringes are formed by interaction of the superimposed markings of the respective single regions, unless the alignment aids are aligned in both translational and angular senses.
2. An article according to claim 1 wherein the adjacent lines of the markings are equi-spaced one from another.
3. An article according to claim 1 or claim 2 wherein the closely spaced lines are in the form of a spiral.
4. An article according to claim 3 wherein the closely spaced lines are in the form of at least two concentric spirals.
5. An article according to claim 1 or claim 2 wherein the arrangement of lines within the said single region comprises a zone of straight parallel lines and a zone wherein the closely spaced lines are in the form of concentric circles.
6. An article according to claim 5 wherein the zone of parallel lines surrounds the zone of concentric circles.
7. An article according to claim 1 or claim 2 wherein the closely spaced lines are in the form of concentric ellipses having a common major axis.
8. An article according to any one preceding claim, the article being a photographic transparency.
9. An article according to any one preceding claim, the article being a printing plate.
10. An article having an alignment aid thereon substantially as hereinbefore described with reference to Figures 1 to 3 or Figures 4 to 7 of the accompanying drawings.
11. An article according to claim 1 and substantially as hereinbefore described.
12. A process for reproducing an image of an original representation comprising the steps of
applying to the original representation an alignment aid so as to create an article in accordance with any one preceding claim,

preparing a plurality of transparencies each representing a component of the original representation and each including a reproduction of the alignment aid,

and reproducing an image of each transparency in turn, successive images being superimposed in accurate alignment by use of the reproductions of the alignment aid.

13. A process according to claim 12 wherein the original representation is a colour photograph, each transparency represents a monochrome component thereof, and each transparency is subjected to colour correction prior to reproduction of an image thereof.

14. A process according to claim 12 wherein the original representation is in colour, each transparency represents a monochrome component thereof, an image of each transparency including the alignment aid is reproduced on a respective printing plate, and a monochrome image of each transparency is printed from its respective plate, successive images being superimposed in accurate alignment by use of reproductions of the alignment aid.

15. A process for the production of a double sided printed circuit board, comprising the steps of

preparing two master transparencies each representing the conductive pattern to be applied to one side of the board,

including on each master transparency an alignment aid so as to create an article in accordance with any one of claims 1 to 8, 10 or 11, the alignment aid being so positioned as to fall outside the boundary of the board when aligned therewith,

superimposing and aligning the two master transparencies on opposite sides of the board by use of superimposed alignment aids, and

transferring the pattern of the two master transparencies to the opposite sides of the board.

16. Any novel and inventive feature or combination of features hereinbefore disclosed.

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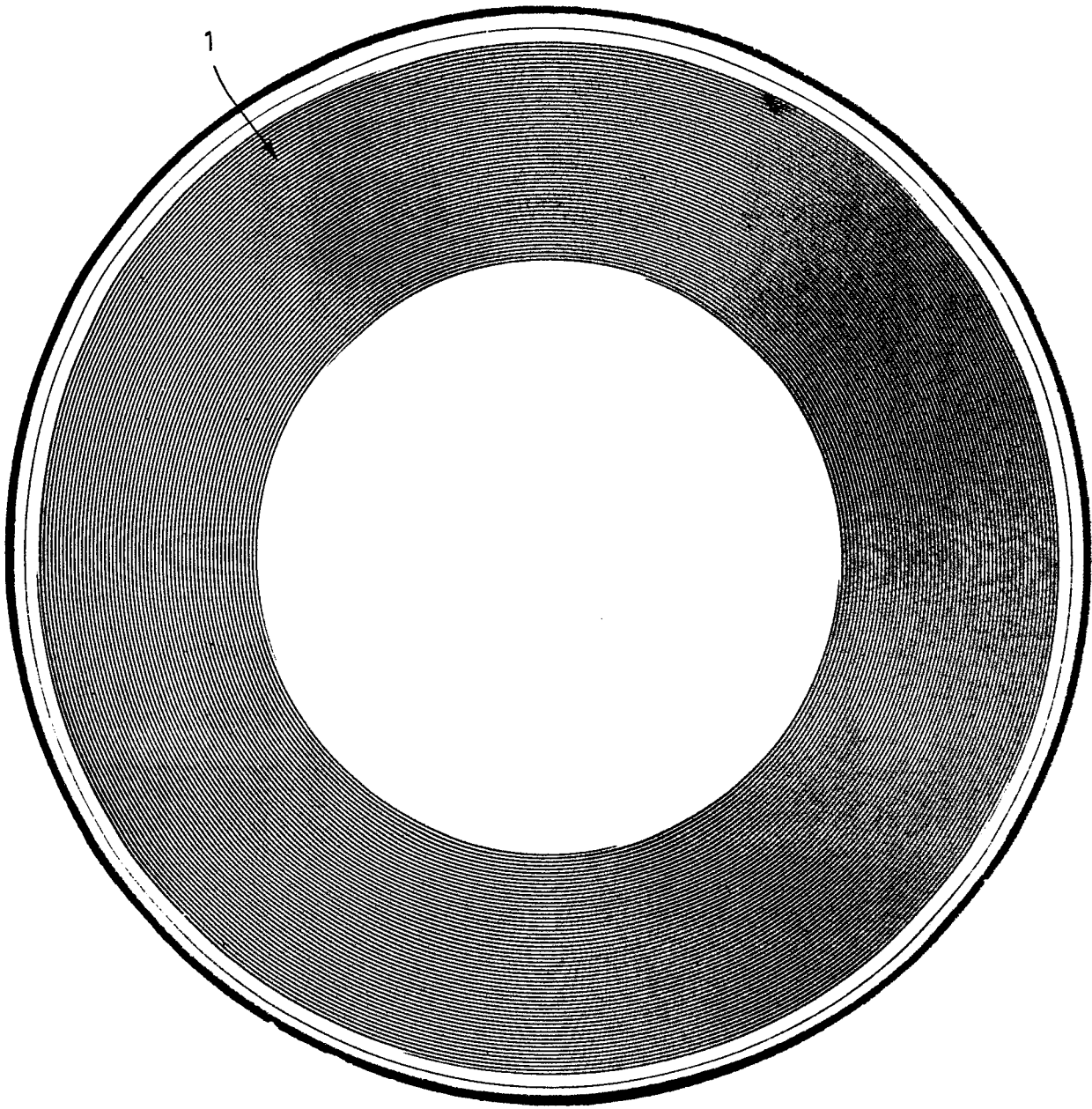


Fig.1.

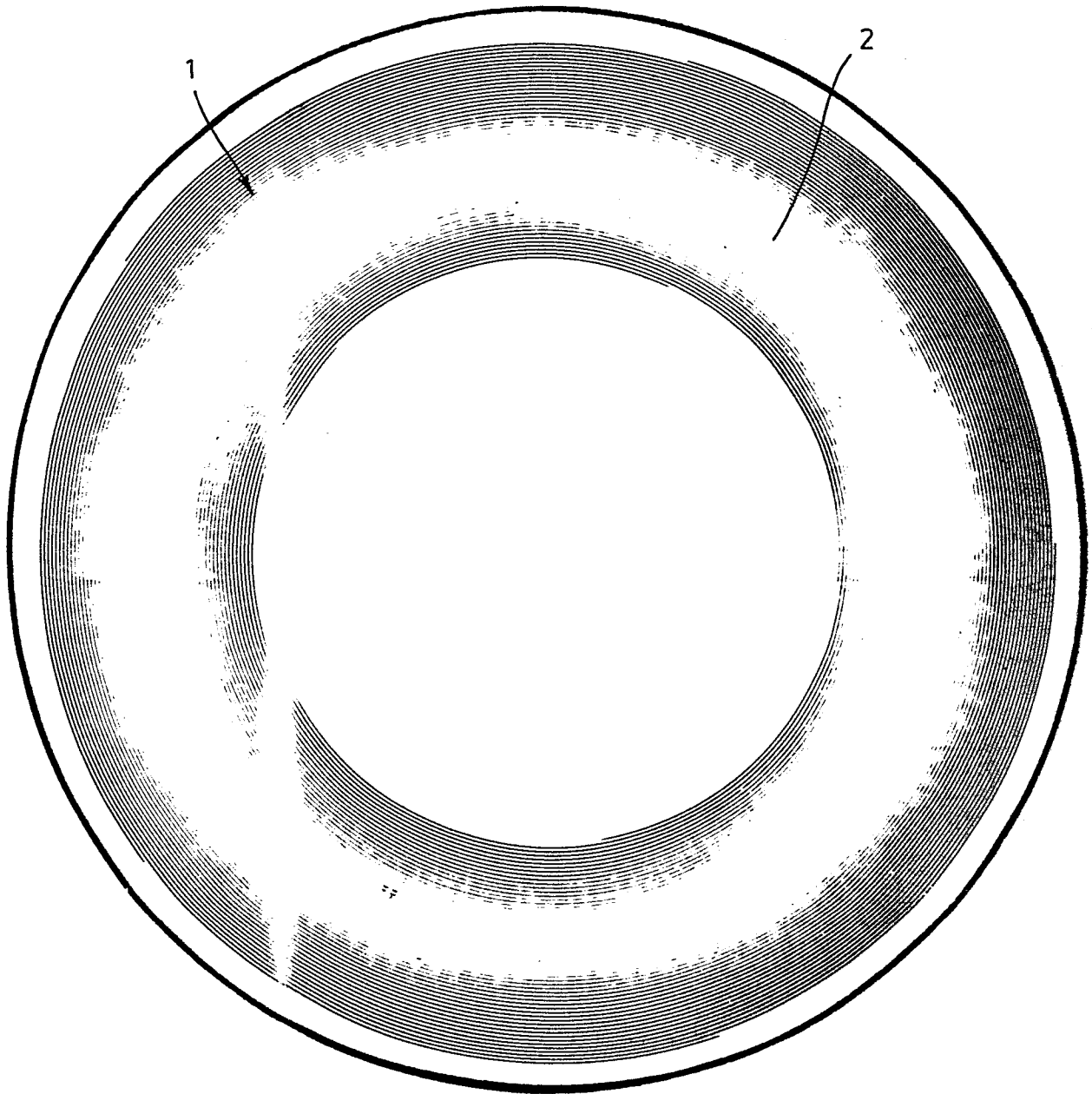
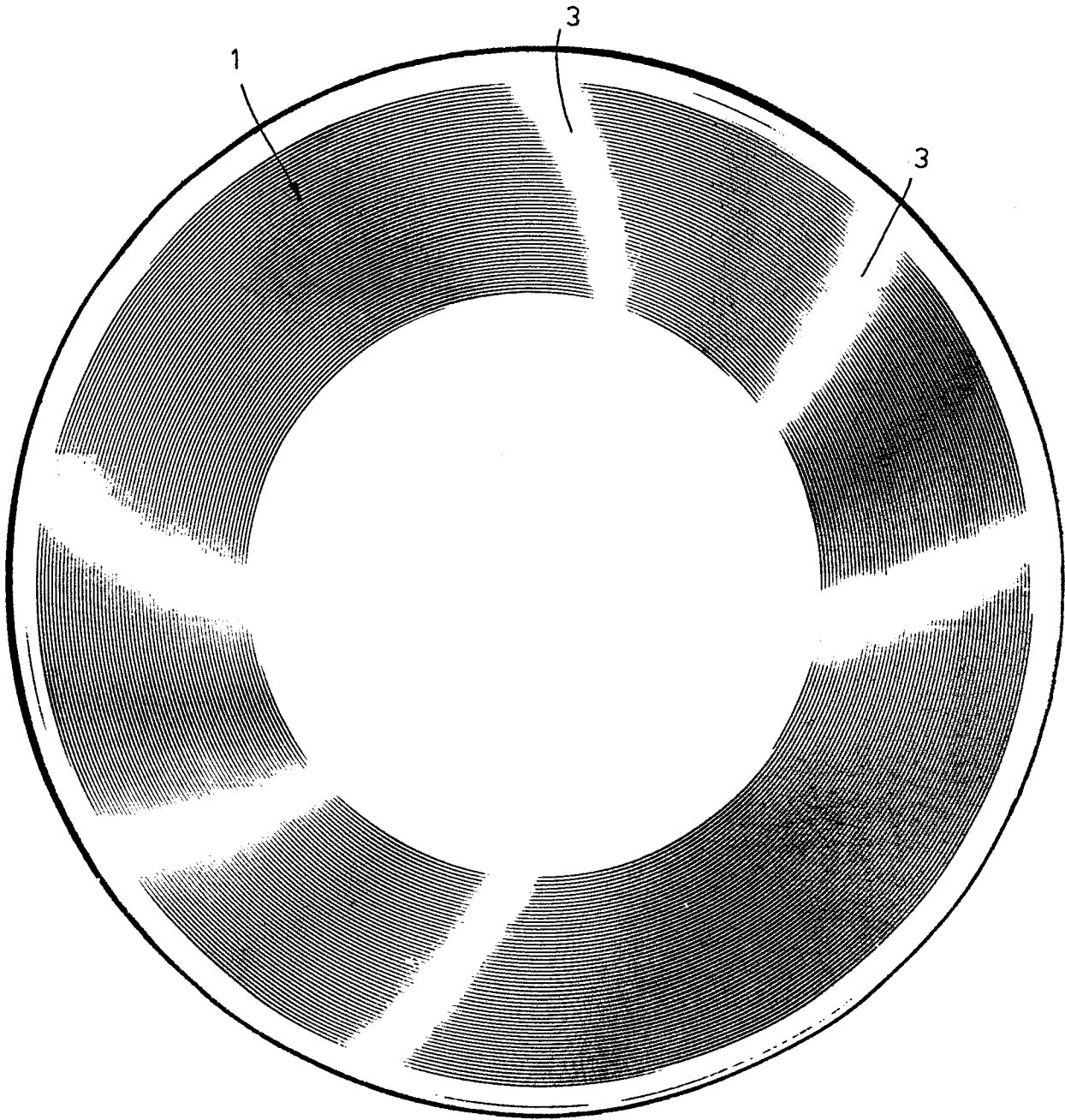


Fig. 2.

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*Fig. 3.*

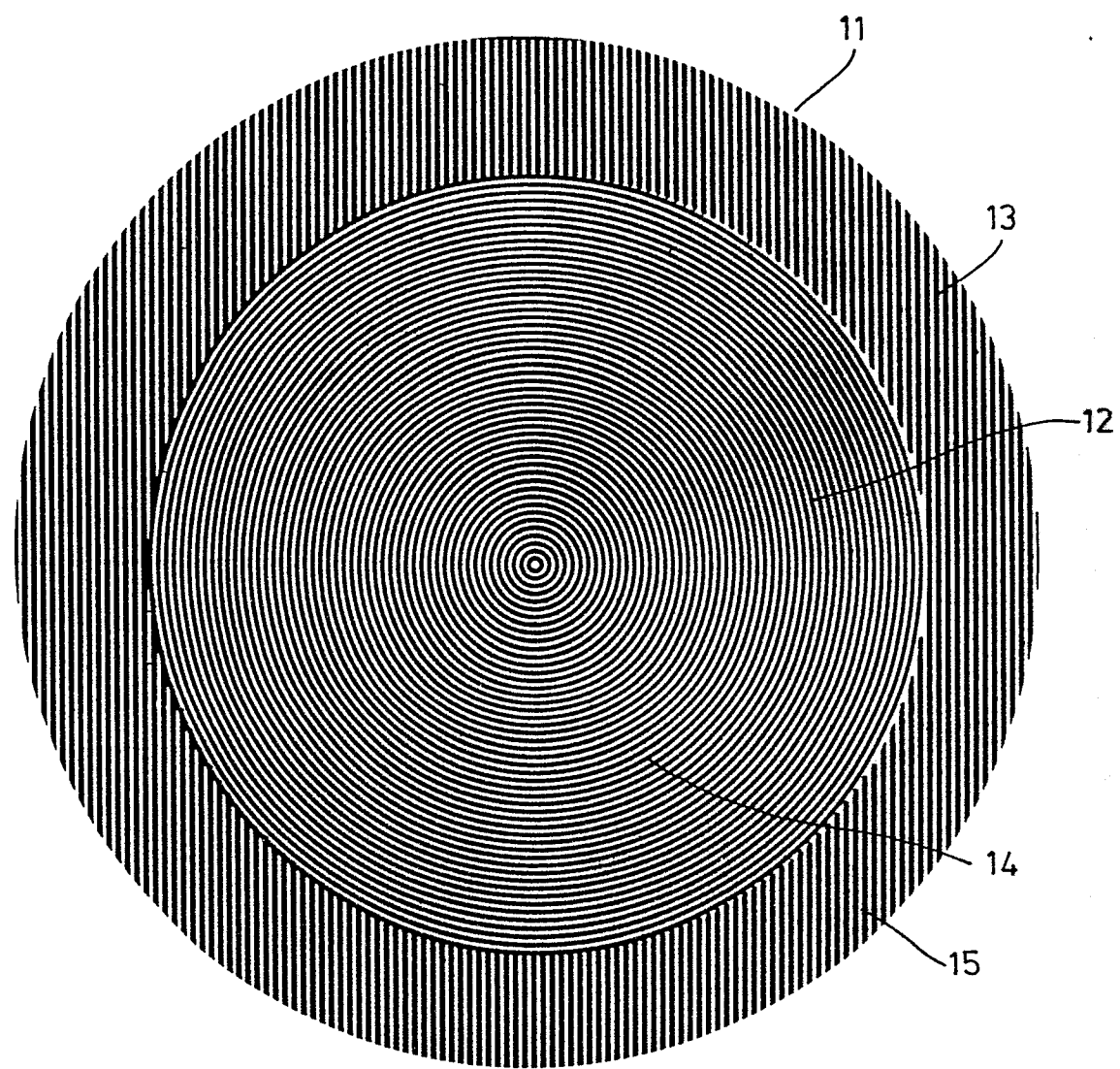


Fig.4.

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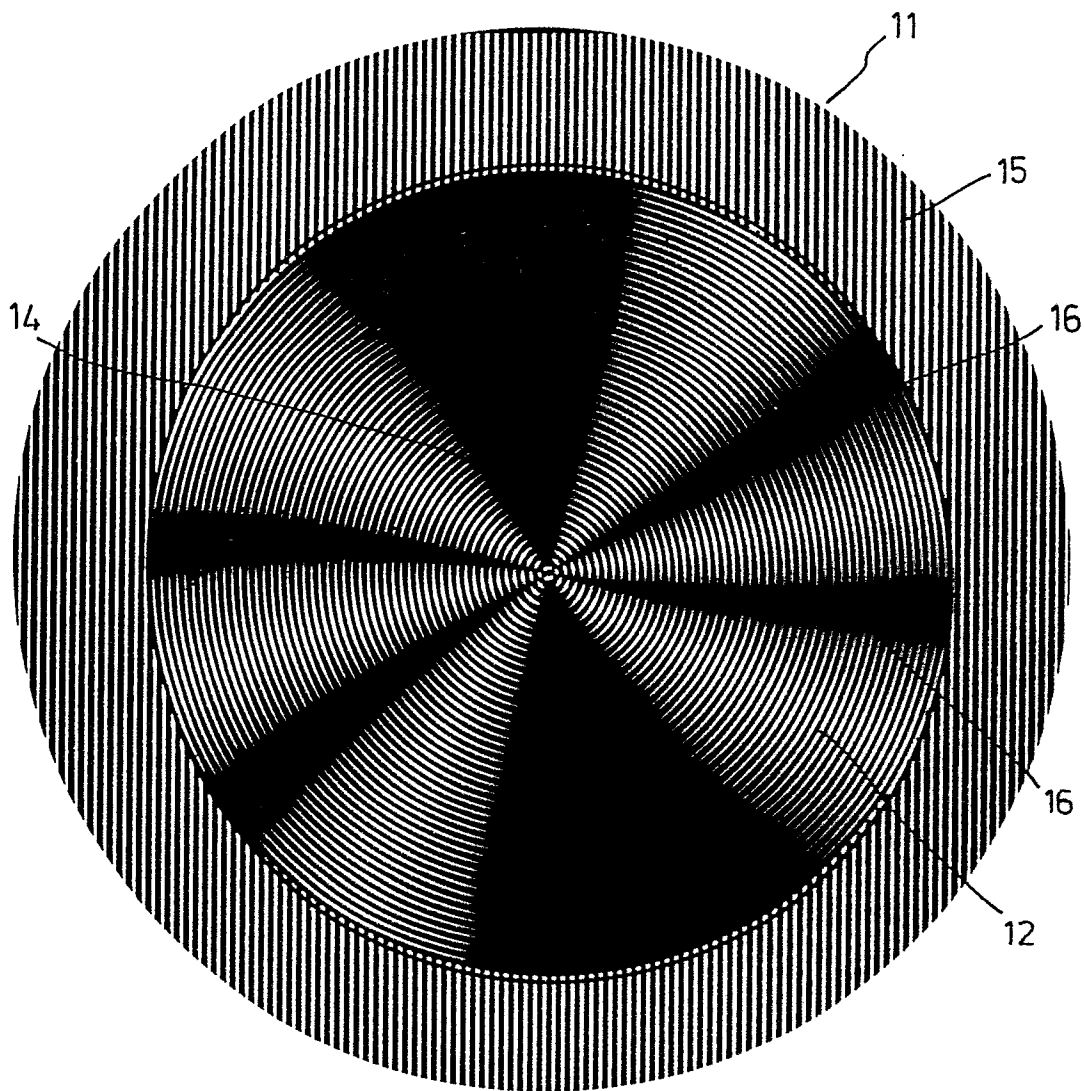


Fig. 5.

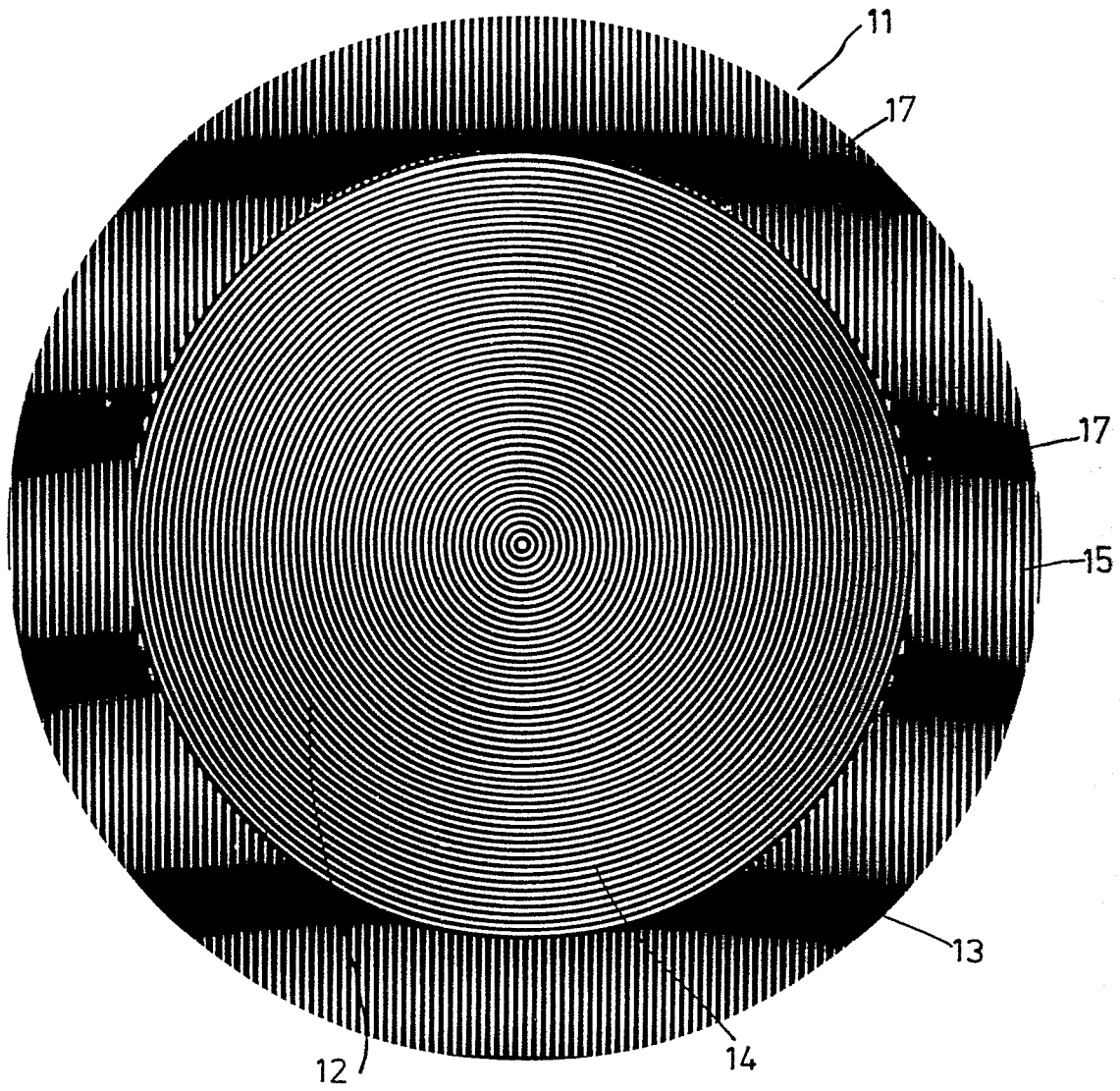
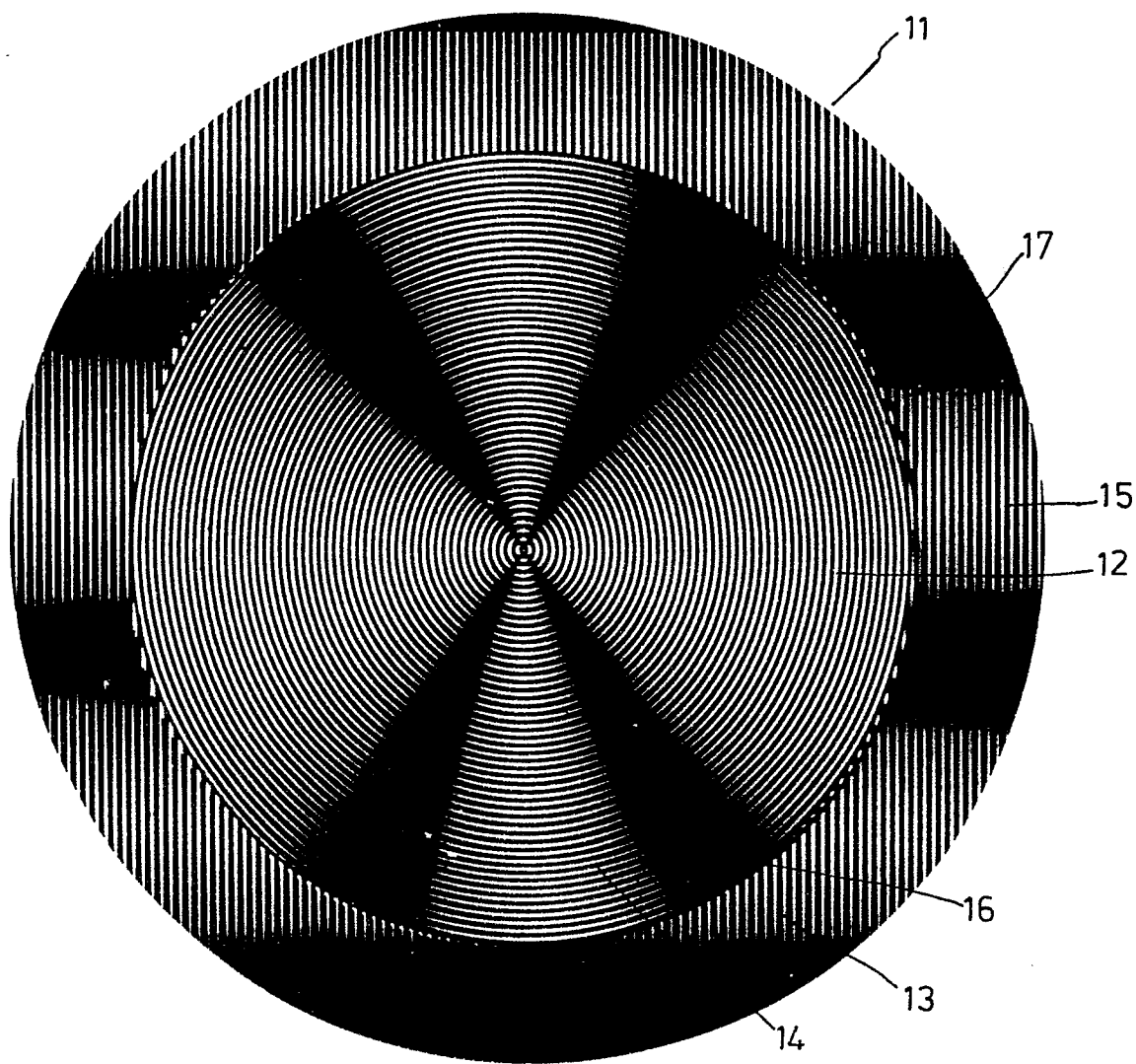


Fig. 6.

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*Fig. 7.*